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(71) Applicant: **Nakano, Kazuo**
1-8-19, Mishuku
Setagaya-ku Tokyo(JP)

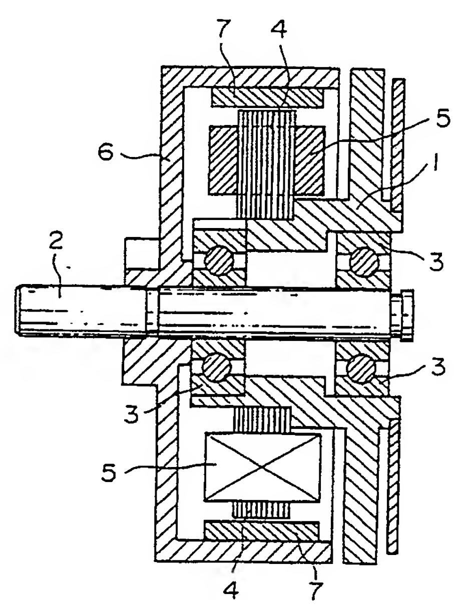
(72) Inventor: **Nakano, Kazuo**
1-8-19, Mishuku
Setagaya-ku Tokyo(JP)

(74) Representative: **Price, Paul Anthony King et al**
D. Young & Co. 10 Staple Inn
London WC1V 7RD(GB)

(54) **SYNCHRONOUS MACHINE.**

(57) A synchronous machine having an armature with n poles, and a field system which rotates relative to the armature, which has n-1 poles to give a field, and which has a plurality of permanent magnets which are magnetized being tilted relative to the circumferential direction and to the axis of said rotational motion.

FIG. 1



EP 0 431 178 A1

SYNCHRONOUS MACHINE

Technical Field

The present invention relates to a synchronous machine which can either take out electric power or create torques by rotating a field which is constituted by magnetized permanent magnets relatively to a coil-wound armature.

Technical Background

The conventional direct current generators, direct current motors, or synchronous generators and, synchronous motors may be classified into two large groups of an armature-rotating type and a field-rotating type, and those in which permanent magnets are used in many cases belong to the latter type. In any of the above the number of the magnetic poles of the field and the number of the armature poles be in an integral ratio such as 1 : 1, or 1 : 2. Also, the permanent magnets as the field poles are magnetized orthogonally against the armature coils, and rotate by themselves. In order to bring the magnetic field in the vicinity of the magnetic poles close to a desired value, some considerations are given usually to the shape of the magnetic poles, air gap, etc.

For instance, in the conventional direct current generators or synchronous generators, since the permanent magnets as the field poles are magnetized orthogonally against the direction of the relative rotation of the armature, the greatest attractive force is created when the magnetic poles and the armature poles face each other directly, but, on the other hand, in the valley between the magnetic poles, since the attractive force suddenly decreeases, strong cogging is created to the rotation of the armature. Therefore, it was disadvantageous that the rotation of the armature cannot be smoothly performed, requiring strong rotating torques for overcoming such coggings.

The object of the present invention is to provide a synchronous generator, a synchronous motor, etc. which can give a large output with a small input, in other words, can show a high operating efficiency by eliminating the aforementioned problems in the conventional generators or motors such that the ratation is not smooth because of the cogging torques being large, and so the generating efficiency is low relative to the mechanical input.

Disclosure of the Invention

The synchronous machine of the present invention comprises an armature having n poles (n being an integer) and (as against this) a field magnet having n - 1 poles, said field magnet being constituted by a plurality of permanent magnets whose magnetization direction is made to coincide with the direction or the reverse direction of rotation of the armature or the field poles; and further, by arranging said plurality of permanent magnets in such a way that they are magnetized inclined against the axis of the rotary motion it is intended that the operation can be carried out by moving the armature and the field poles relatively to each other.

Since the number of the armature poles is n (n being an integer) and that of the permanent magnets poles constituting the field is n - 1, only one pair of these poles of the permanent magnets and the armature can face each other directly, but no other pair can do so at the same time. Further, since the poles of the permanent magnets are inclined against the axis of the rotary motion of the field constituted by said permanent magnets, the substantial attractive force created between both the paired poles does not vary drastically within the range of the angle crossed over before and after the aforementioned pair of poles face each other.

Brief Explanation of the Drawings

The drawings show a generator of rotating-field type as one embodiment of the present invention. Fig 1 is a sectional view of the whole, Fig. 2 is a front view of an armature core, Fig. 3 shows a concrete example of a coil-wound armature having 9 poles, Fig. 4 is a front view of permanent magnets constituting a field, Fig. 5 is a partially exploded view showing the magnetized state of the magnets, Fig. 6 is a circuit diagram showing the state of measurement, and Fig. 7 is characteristic graph showing the generated voltages, currents, and torques against the loads at varying roatation speeds.

Best form in Practice of the Invention

With reference to the drawings, the examples of the present invention will be explained below.

In Fig. 1, the numeral 1 denotes a hollow fixed shaft through which a rotating shaft 2 penetrates which is borne rotatably by a bearing 3.

On the fixed shaft 1 is fixed an armature core 4 having 9 poles (n = 9 in this example) formed thereon as shown in Fig. 2, each of said poles n_1 - n_9 being coil-wound. Fig. 3 illustrates the winding method for an odd number of poles. The winding and connecting wires in phase A are represented with a solid line ----, those in phase B with a chain

line ----, and those in phase C with one-dot-chain line - - - -. As one phase is thus formed of three winding wires, 9 poles n_1 - n_9 are covered by 3 x 3. In the sectional view in Fig. 1, armature coils are represented by 5.

In order that a field may be formed on the rotating frame 6 secured on the rotating shaft 2, a plurallity of permanent magnets 7 are fixed so as to be positioned adjacent to the periphery of poles 4a of the aforementioned armature core 4.

The permanent magnets 7 are arranged in such a way that the N and S poles are positioned alternately on the inner surface as shown in Figs. 4 and 5, and slantly magnetized relative to the center line, or the rotating axis of the cylindrical form thereof, as shown in Fig. 5.

The number of poles of the permanent magnets 7 is n 1 = 9 - 1 = 8, and accordingly, an 8-poled field is formed. Therefore, among the poles of the permanent magnets and the poles n_1 - n_9 of the armature core 4, only one pair of them can face each other, but no other pole can do so at the same time.

Further, since the poles of the permanent magnets 7 are inclined against the axis of the rotary motion of the field constituted by said permanent magnets 7, the substantial attractive force created between both paired poles does not vary drastically within the range of the angle crossed over before and after the aforementioned pair of poles face each other.

When, for example, the S pole of a certain permanent magnet 7 constituting the field has passed by the position of, for example, n_1 in Fig. 3, and the attractive force between the paired poles is weakened, the repulsive force is increasingly created between the next position and n_2 another pole, which is an N pole, of the permanent magnet 7, so that the decrease in the substantial attractive force can be offset.

Thus, this gives such a relationship as close to the case where a pair of poles face each other directly, and therefore, the variation of the cogging torques due to the sudden changes in the attractive force of the armature pole 4 caused by the pole of the permanent magnet 7 constituting the field is very little.

Also, as shown in the circuit diagram in Fig. 6, coils 5 are connected together at each one end, forming a Y-connection.

While, the other ends of said coils are connected respectively with the intermediate point between two diodes, i.e., D_{1a} and D_{1b}, D_{2a} and D_{2b}, and D_{3a} and D_{3b}, said D_{1a}, D_{2a} and D_{3a} and said D_{1b}, D_{2b} and D_{3b} being respectively combined and connected through a common line, and a load R is connected with the common line.

Thus, there is obtained a direct current generator, in which only a unidirectional current can flow through said load R.

Further, as described above the inclination in the poles of the permanent magnets constituting the field as reduces the variation in the magnetic flux density produced at the armature poles 4 before and after they face the magnetic poles. Thus, the electric current generated in coils 5 is found to be almost flat, and as the result the ripple voltage involved therein can also be reduced.

Fig. 7 shows the generated voltages, currents, and rotating torques corresponding to the number of rotations of the rotating shaft 2 at the time when a voltmeter V and an ammeter A are connected to this generator as shown in Fig. 6, with the load resistance R at 0, 10, 100, 470, 1000 and infinite ohms.

Meanwhile, in the present experiment there are employed an amature core 4 of 39.4 mm in outer diameter, permanent magnets 7 of 40 mm in inner diameter, which constitute the field, coils 5 of 140 turns of 0.16 mm insulated copper wire, and a coil-wound resistance of 9.3 ohms.

Furthermore, in the present invention, the object which rotates/or the rotor, may be the armature on the inside instead of the permanent magnets 7 on the outer side which constitute the field, in which case the conventional brushing means may be adopted in taking out the electric power.

Although the above explanation has been given solely to the generators, since the generators and the motors are essentially the same in the mechanism, it is needless to say that the same may also be applied to the motors.

Industrial Applicablity

According to the present invention, for example, by making the direction of magnetization of the plurality of permanent magnets constituing the field of the generator of rotating-field type coincide with the direction of rotation of the field magnets or the armature, and moreover, by inclining the magnetized poles of said plurality of permanent magnets against the axis of the aforementioned rotary motion, the NS magnetic path can be elongated and the magnetic field distribution between N and S can be broadened. At the portion crossed over between an N pole and the neighboring S pole, the cogging torque is reduced since the attractive force of the N pole and the repulisive force of the S pole offset each other. Furthermore, because of that of the armature poles being n, while that of the permanent magnets which constitute the field being n - 1, only one pair of the armature pole and the magnet pole can face each other directly, and this also contributes to the reduction of the cogging torques.

Thus the cogging loss may be minimized.

If a static induction transistor (SIT) or the like, which shows little loss is used as a rectifier element, there will be further reduced loss. Since permanent magnets are used, exciting current loss is also nil.

On the other hand, as the magnetic field flux density crossing the armature coil is broadened as well as flattened at its peak area, the wave form becomes almost trapezoidal, so that when the current is converted into a direct current through diodes, the conversion efficiency is excellent.

In other words, the synchronous machine of the present invention is excellent not only in that both the mechanical and electrical energy losses are very little but also in that it can supply a large output with a small input.

Claims

1. A synchronous machine comprising an armature having n poles (n being an integer) and a field constituted by a plurality of permanent magnets, said permanent magnets having n - 1 poles which can provide a magnetic field by rotating relatively to said armature, and being arranged in such a way that they are magnetized along the peripheral direction and at the same time inclined the axis of the aforementioned rotary motion.

FIG. 1

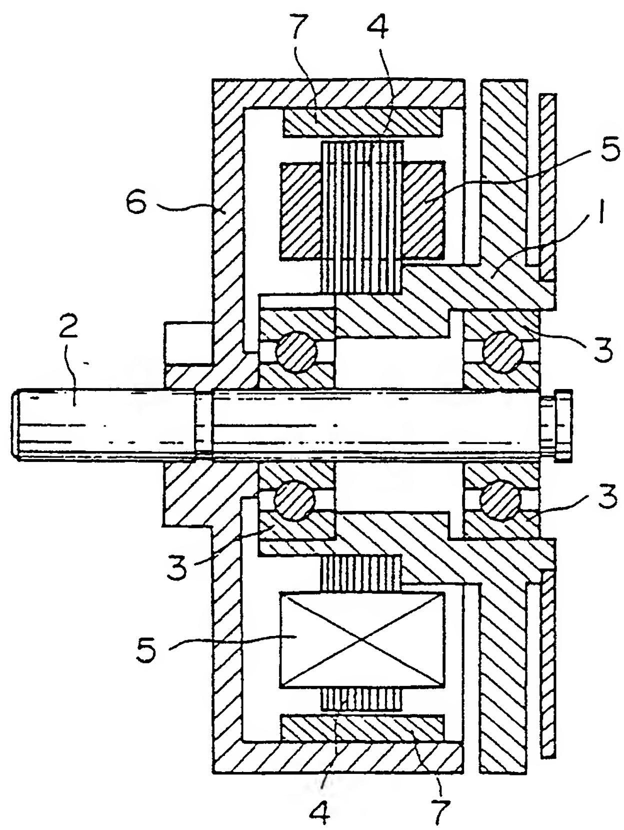


FIG. 2

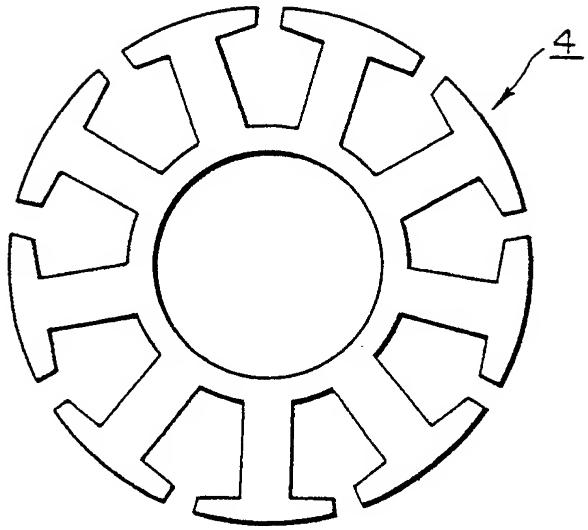


FIG. 3

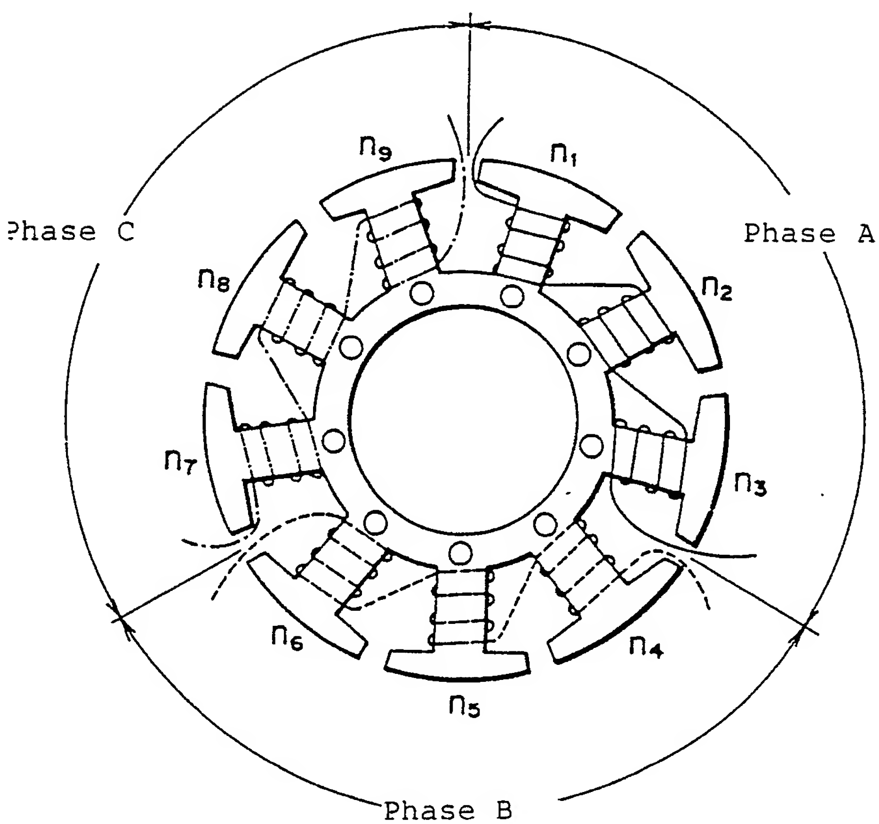


FIG. 4

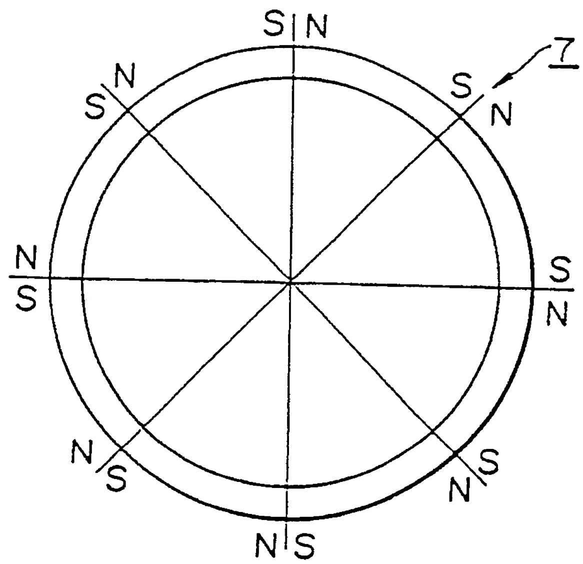


FIG. 5

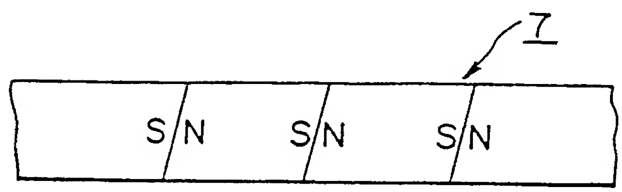


FIG. 6

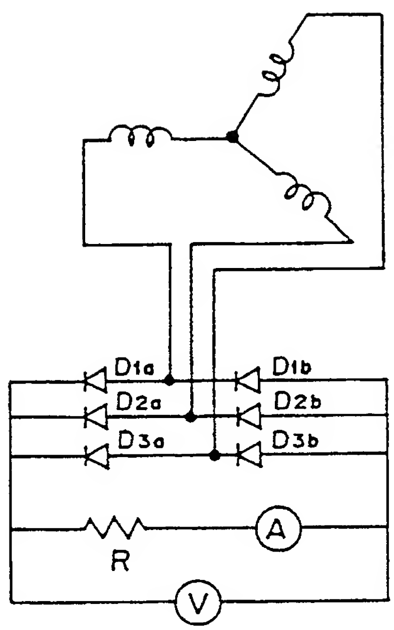
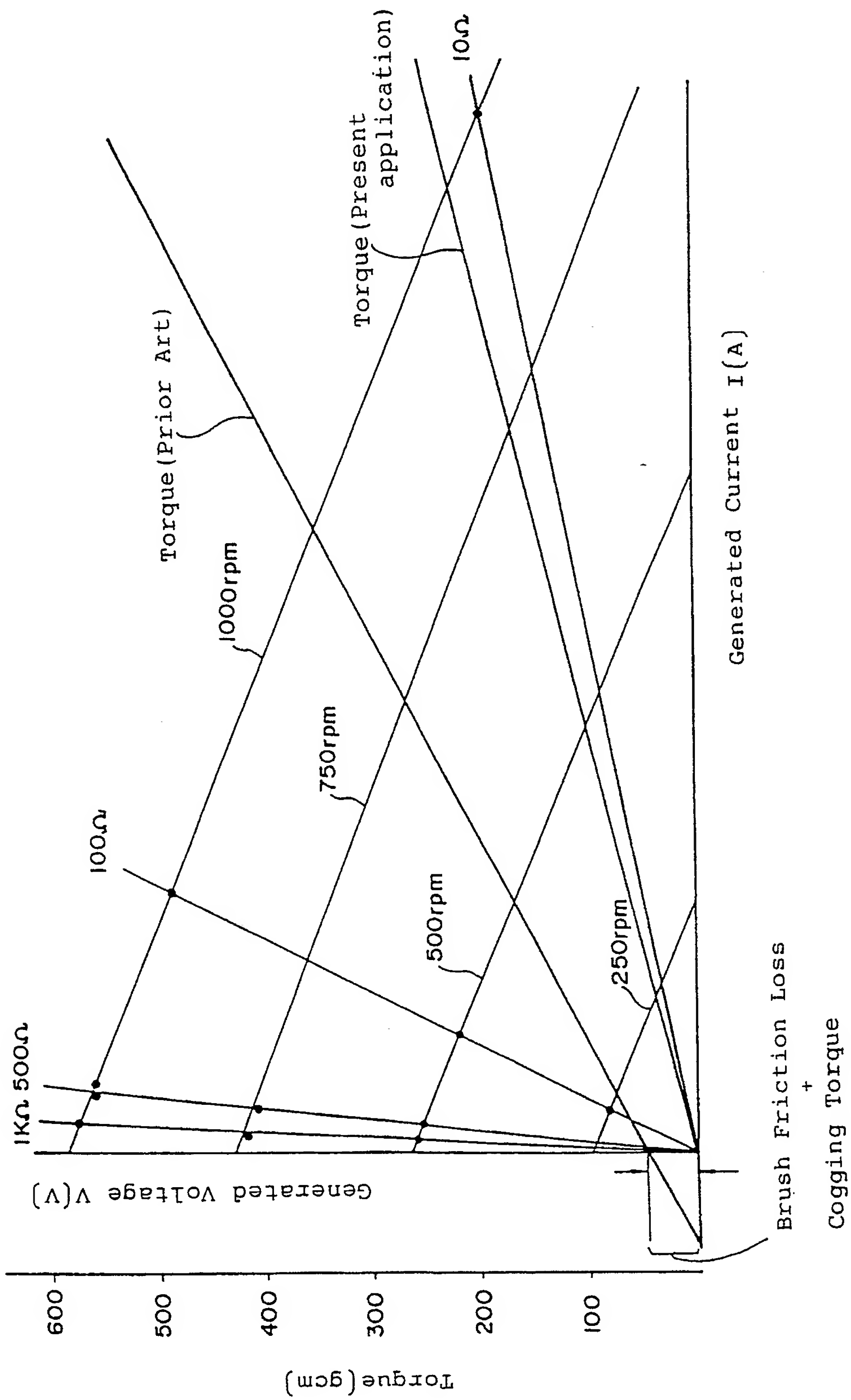


FIG. 7


Torque (Present application)
10Ω
Torque (Prior Art)
Generated Current I(A)
1000rpm
750rpm
100Ω
500rpm
250rpm
1KΩ 500Ω
Generated Voltage V(V)
Brush Friction Loss
+
Cogging Torque
600
500
400
300
200
100
Torque (gcm)

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/00713

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^5 H02K21/22

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	H02K21/22, 29/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1950 - 1990
Kokai Jitsuyo Shinan Koho	1972 - 1990

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	JP, A, 59-220061 (Yoshiteru Takahashi), 11 December 1984 (11. 12. 84), Line 19, lower right column, page 278 to line 4, lower right column, page 279, Figs. 6, 7 (Family: none)	1
Y	JP, A, 59-44957 (Hitachi, Ltd.), 13 March 1984 (13. 03. 84), Lines 7 to 17, lower left column, page 291 (Family: none)	1

* Special categories of cited documents: [10]

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
August 18, 1990 (18. 08. 90)	September 3, 1990 (03. 09. 90)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	